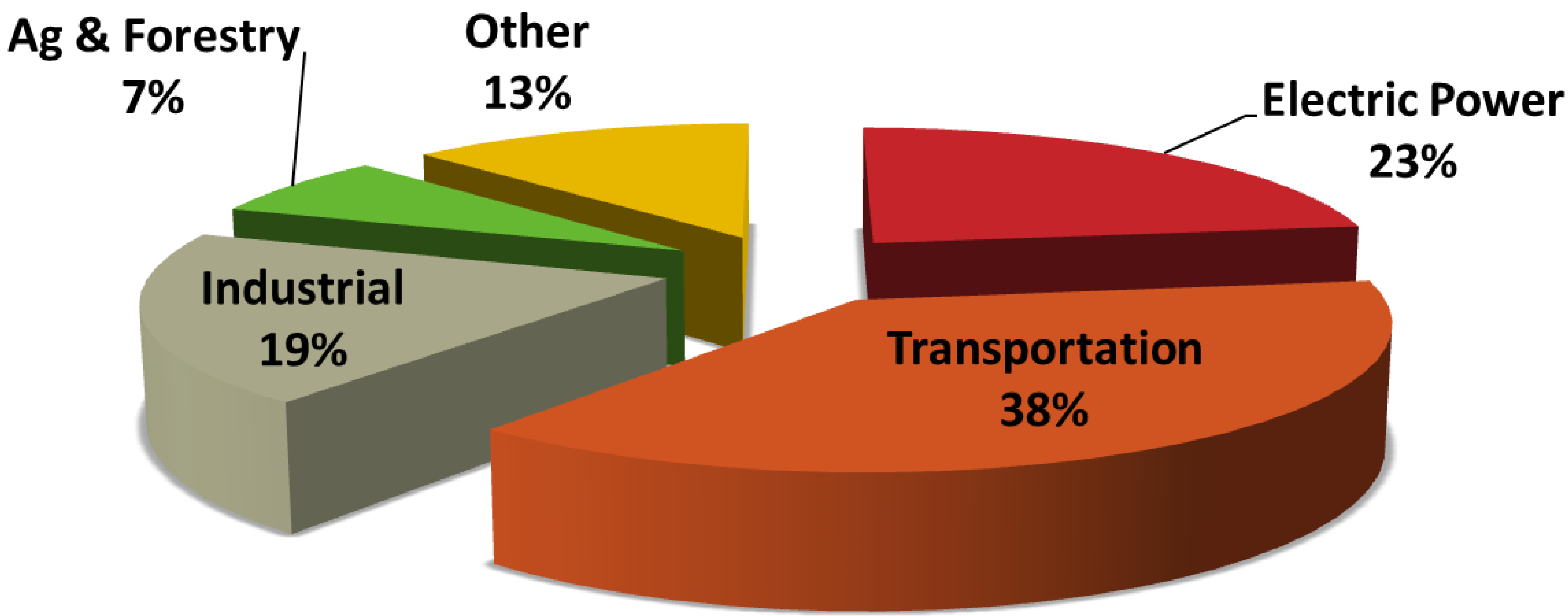
Greenhouse gas mitigation options for California Agriculture

Johan Six

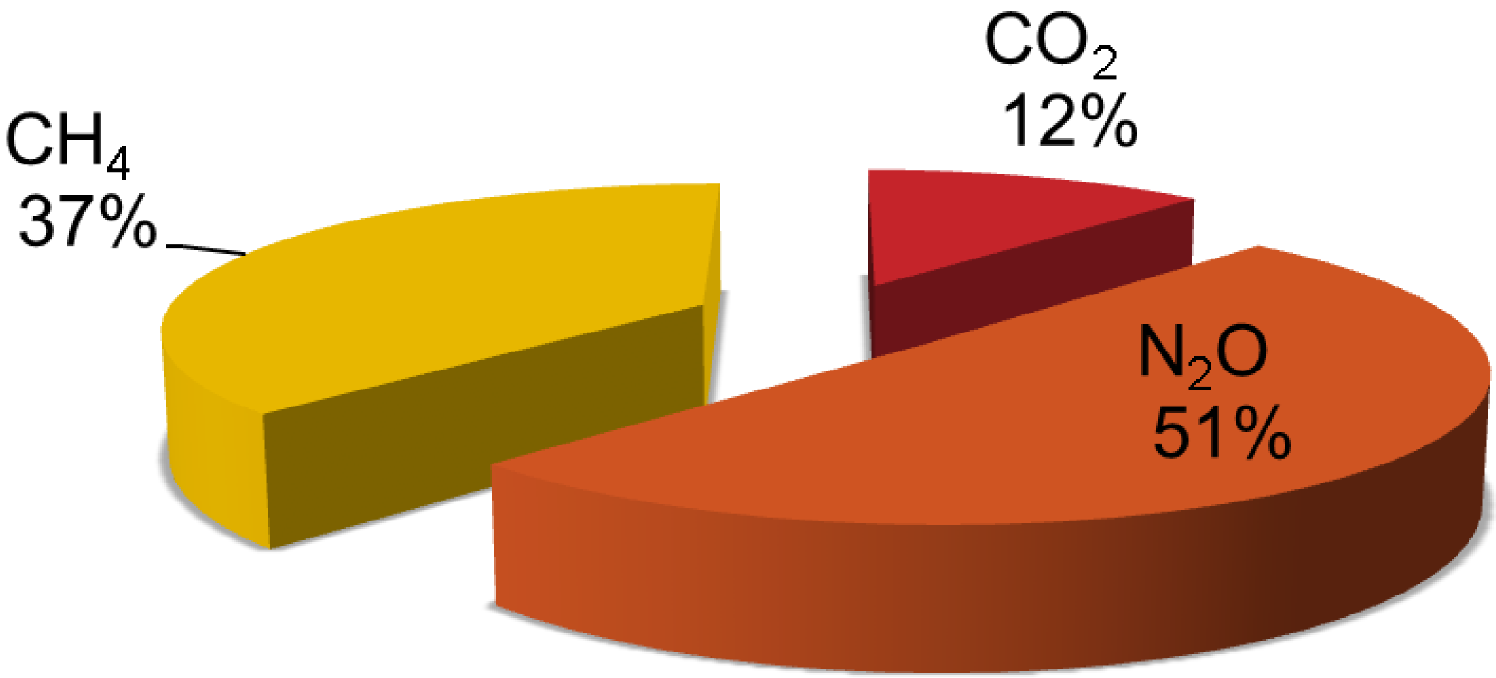
UC DAVIS
PLANT SCIENCES

Sources of greenhouse gases in CA



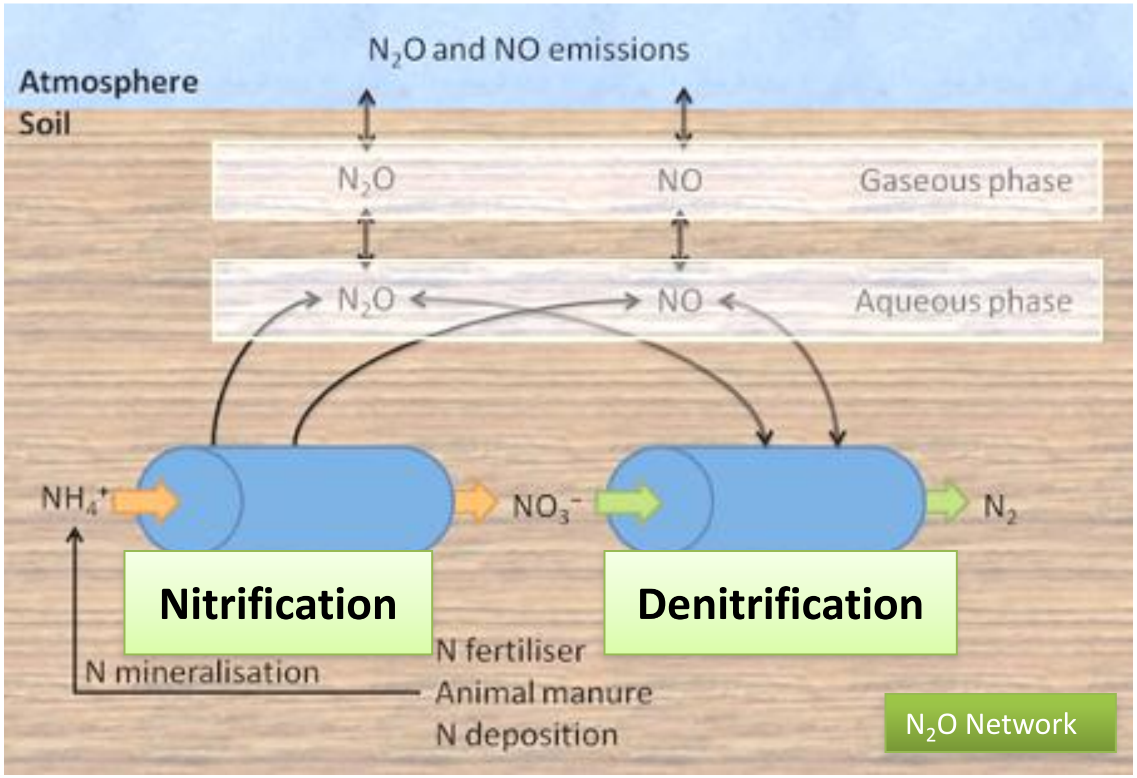
California Air Resources Board, 2009

Composition and sinks of greenhouse gases by agriculture



California Air Resources Board, 2009

N_2O Substrates



1. **Soil Moisture (WFPS)**
2. **Inorganic N (NH_4^+ & NO_3^-)**
3. **Soil Organic Carbon (SOC)**

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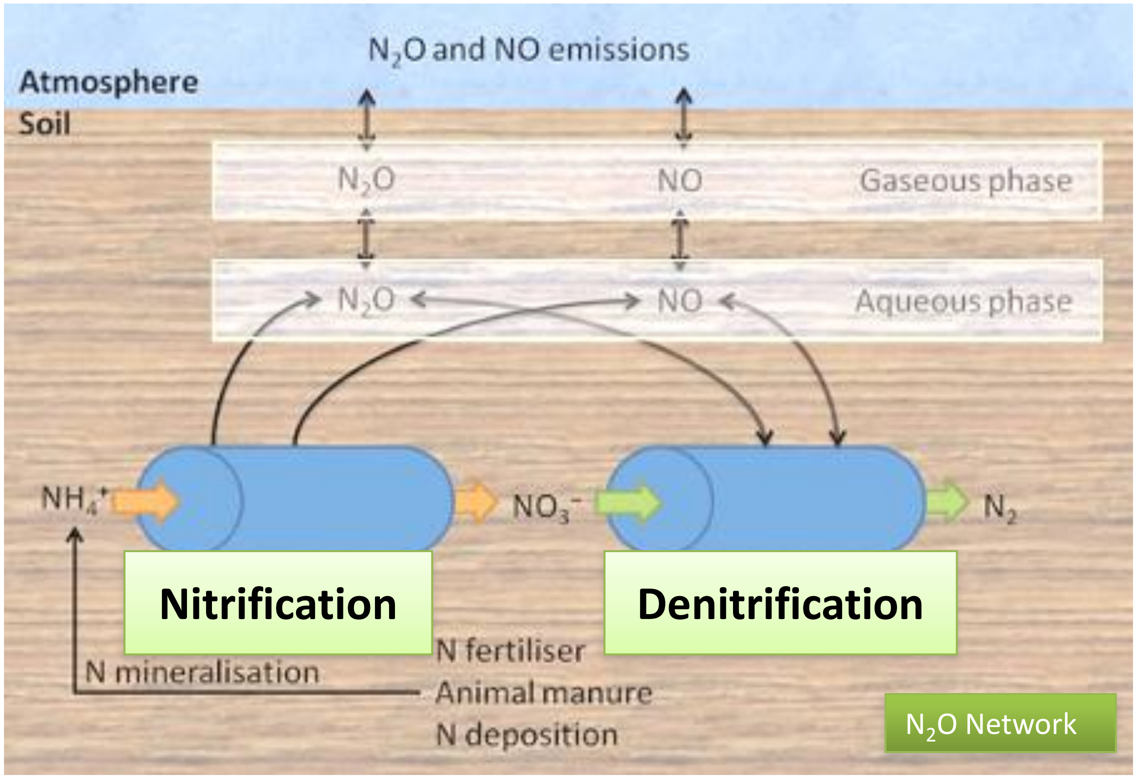

1. **Soil Moisture (WFPS) — IRRIGATION/RAIN**
2. **Inorganic N (NH_4^+ & NO_3^-) — FERTILIZATION**
3. **Soil Organic Carbon (SOC) — TILLAGE**

Management changes (regional)

Fertilizer	Cover crop	Tillage	ΔGWP (Mg CO_2-eq ha^{-1} yr^{-1})		ΔSOC (kg C ha^{-1} yr^{-1})		ΔN_2O (kg N ha^{-1} yr^{-1})	
			Sacramento Valley *					
Mineral, (25% reduction)	no	CT	-0.89	± 0.76	-2	± 16	-1.92	± 1.59
Mineral	no	RT	-0.68	± 0.36	+103	± 34	-0.64	± 0.56
Mineral	yes	CT	-1.36	± 0.89	+310	± 180	-0.48	± 0.94
Mineral	yes	RT	-1.37	± 0.88	+312	± 178	-0.48	± 0.94
Organic	no	CT	-1.16	± 0.78	+158	± 63	-1.23	± 1.51
Organic	no	RT	-1.94	± 1.03	+288	± 88	-1.89	± 1.86
Organic	yes	CT	-2.60	± 1.87	+405	± 212	-2.38	± 2.81
Organic	yes	RT	-3.29	± 2.07	+532	± 246	-2.86	± 2.98

CT = Conventional Tillage; RT = Reduced Tillage

*Crops Included: Rice, Alfalfa, Cotton, Tomatoes, Winter Wheat, Corn, Safflower

De Gryze et al 2011 AGEE

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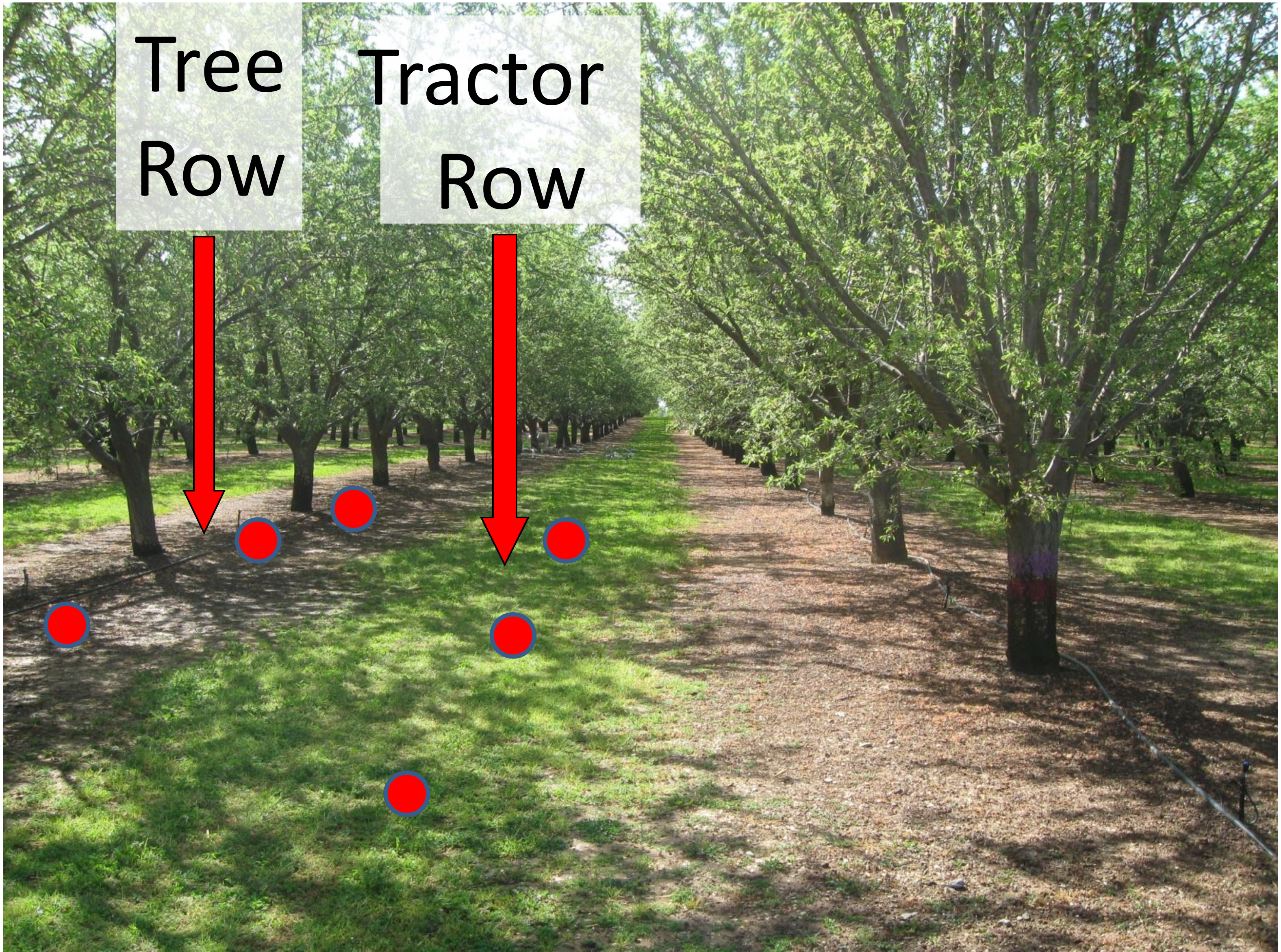
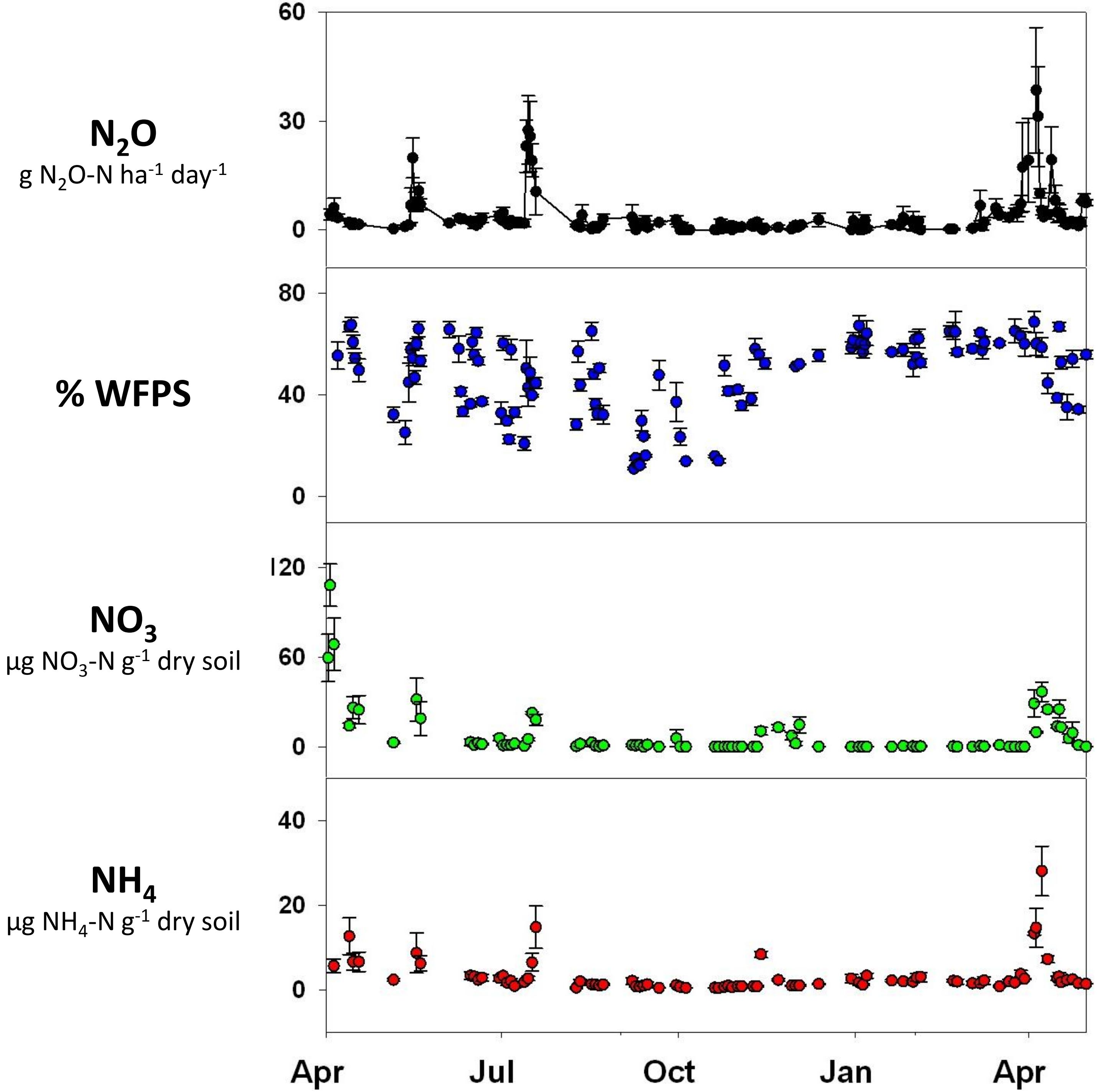
Status of N_2O budgets (2009)

Cropping System	# observations in literature	
Corn	157	
Rice	78	
Wheat	77	
Alfalfa	4	
Cotton	5	
Tomato	6	
Fruit Orchards	0	
Nut Orchards	0	→ 2 published
Vineyards	0	→ 3 published 2 in progress

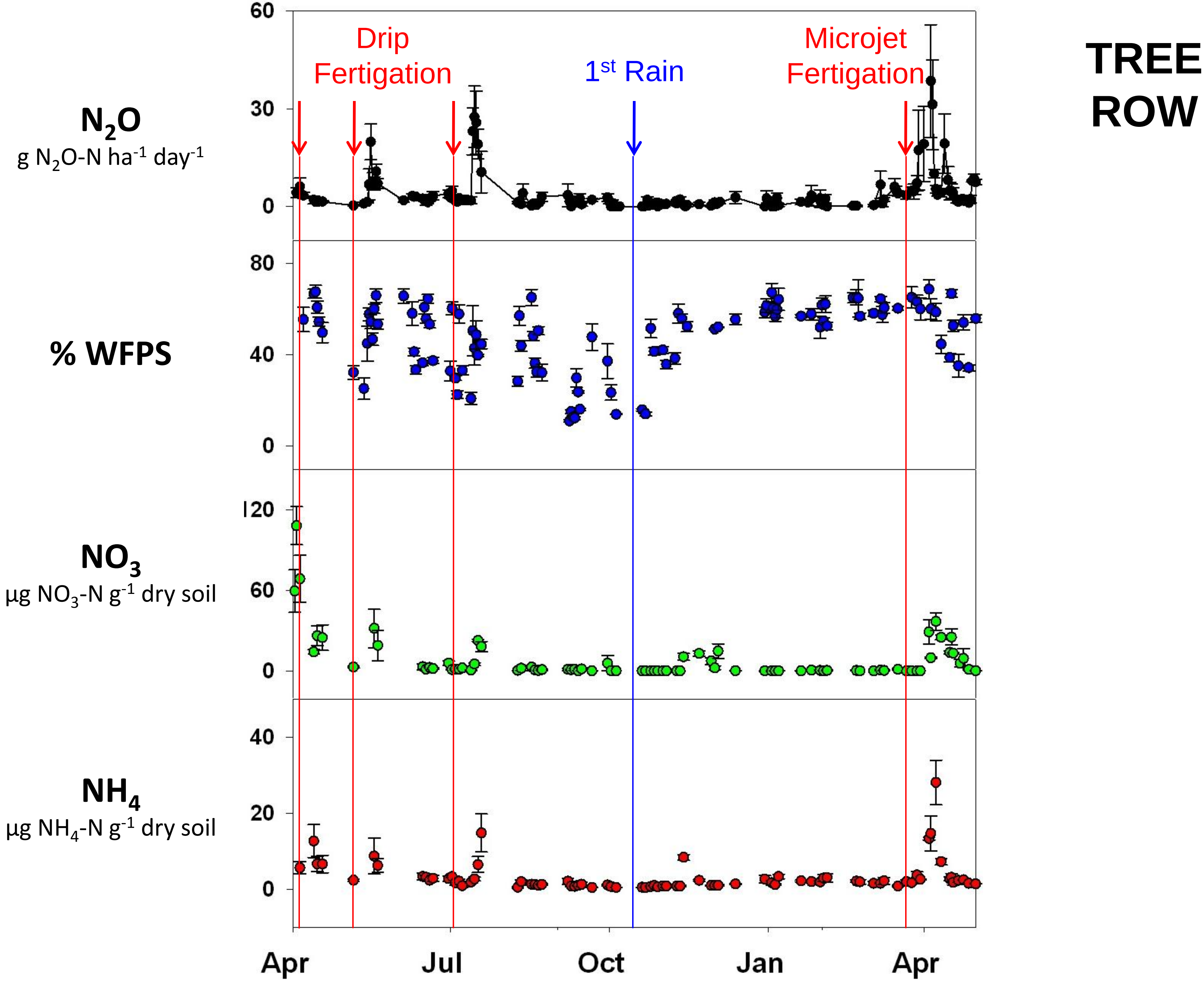
Almond orchard

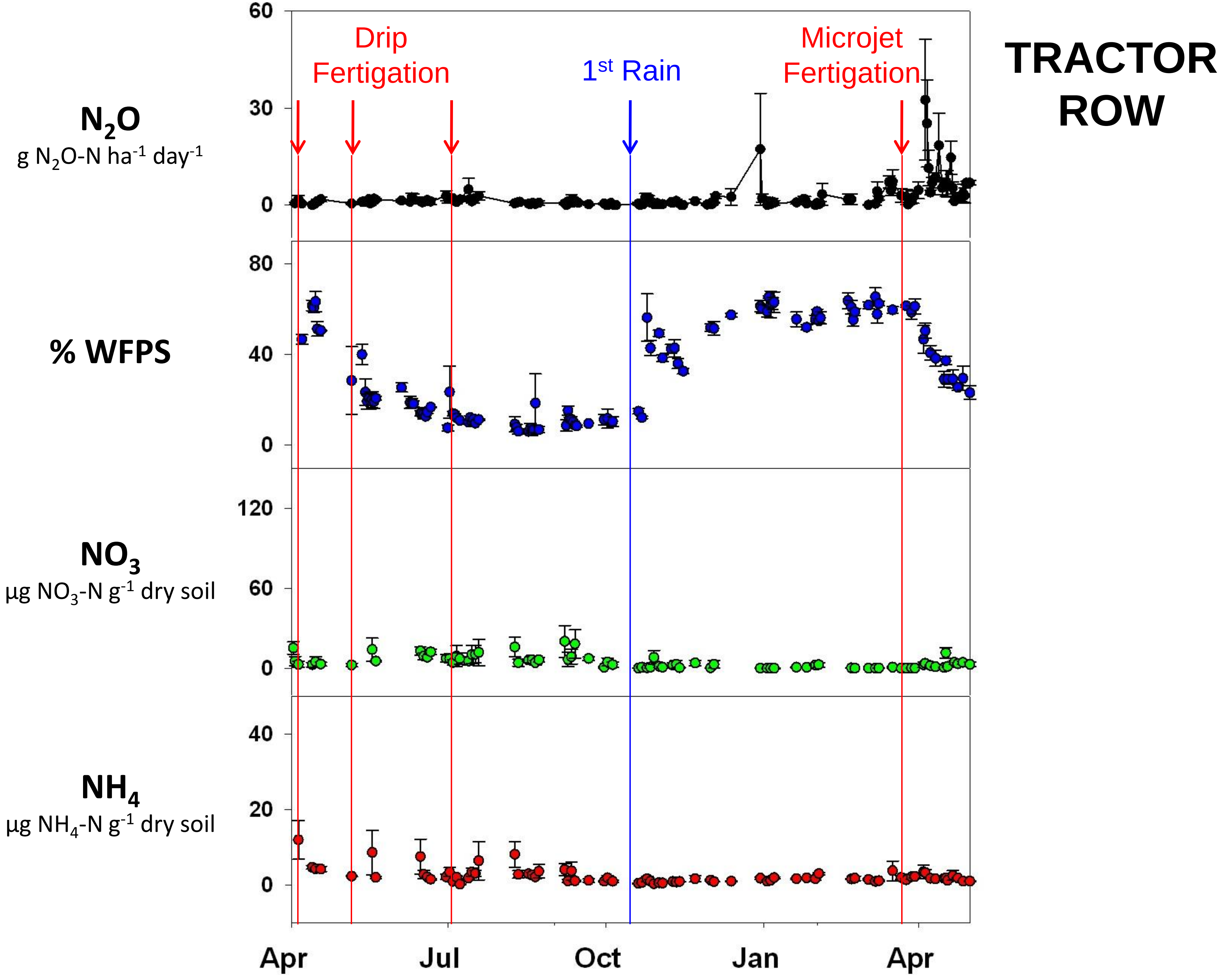


TREE ROW



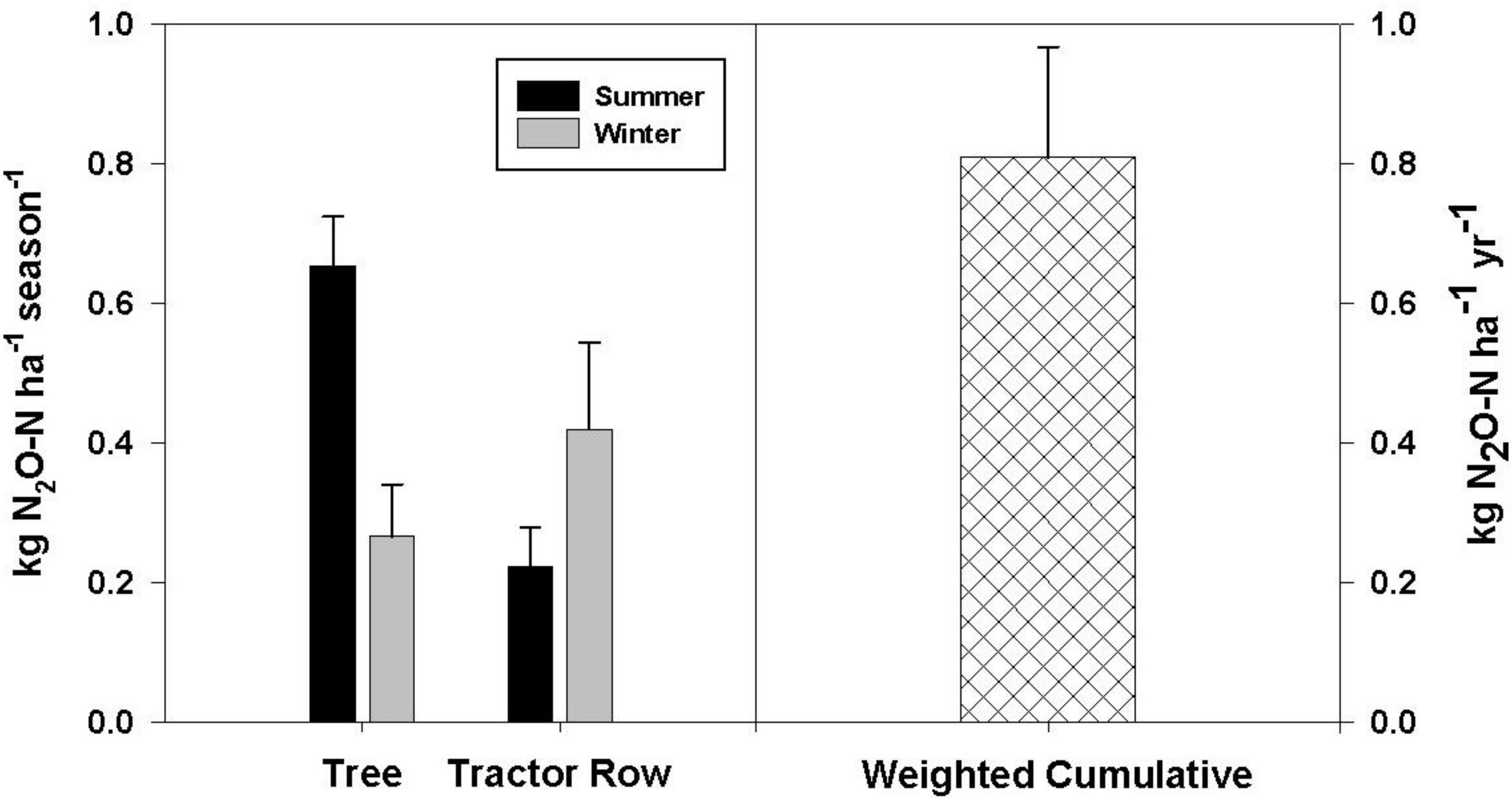
N_2O
g N_2O-N ha^{-1} day^{-1}
% WFPS
NO_3
µg NO_3-N g^{-1} dry soil
NH_4
µg NH_4-N g^{-1} dry soil
60
30
0
80
40
0
120
60
0
40
20
0
Apr
Jul
Oct
Jan
Apr


TREE ROW
N_2O
g N_2O-N ha^{-1} day^{-1}
% WFPS
NO_3
μg NO_3-N g^{-1} dry soil
NH_4
μg NH_4-N g^{-1} dry soil
Drip Fertigation
1^{st} Rain
Microjet Fertigation
60
30
0
80
40
0
120
60
0
40
20
0
Apr
Jul
Oct
Jan
Apr

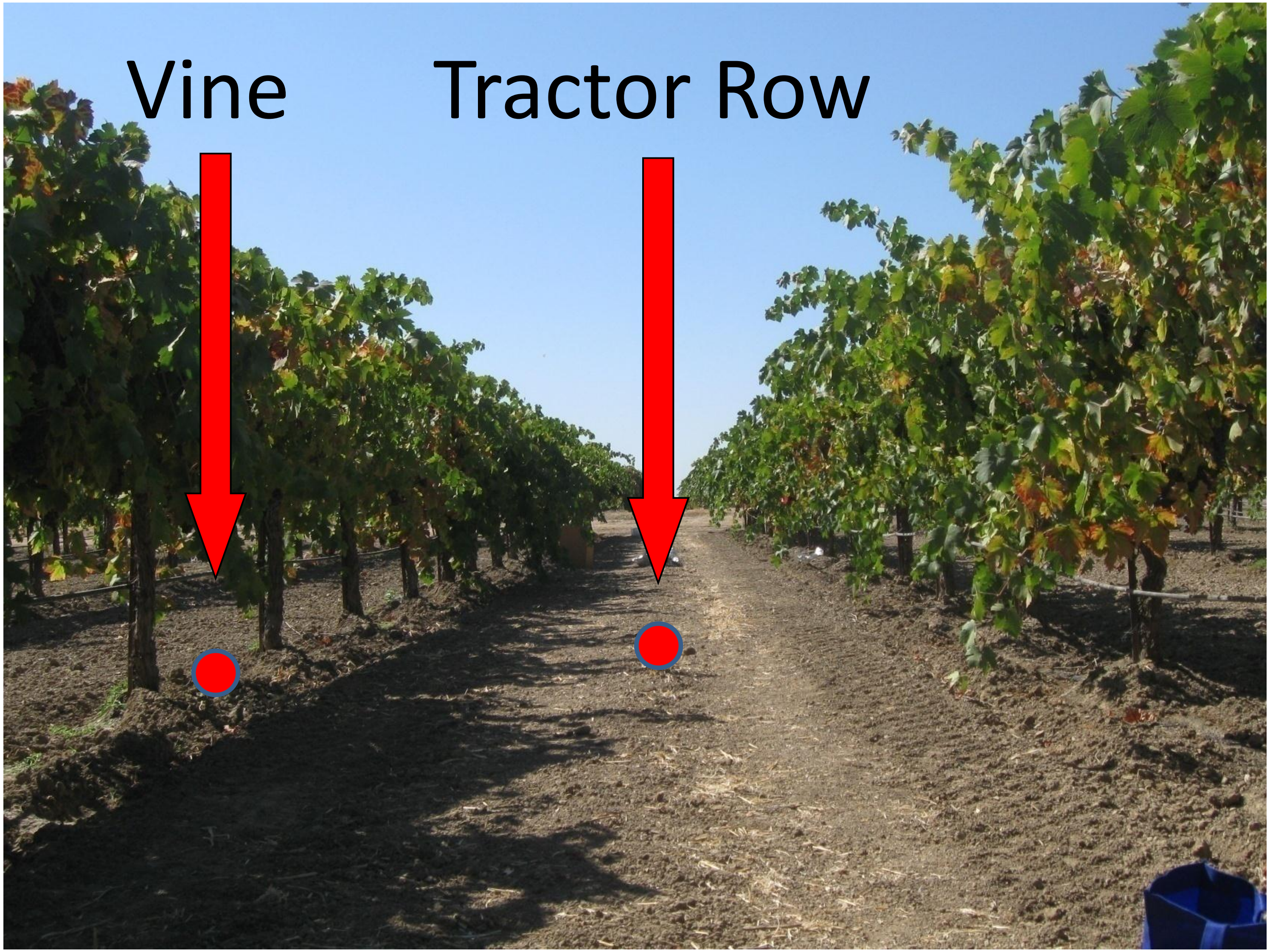


TRACTOR ROW
N2O
g N2O-N ha-1 day-1
% WFPS
NO3
µg NO3-N g-1 dry soil
NH4
µg NH4-N g-1 dry soil
Drip Fertigation
1st Rain
Microjet Fertigation
60
30
0
80
40
0
120
60
0
40
20
0
Apr
Jul
Oct
Jan
Apr

Cumulative N_2O emissions: Almond



Vineyard



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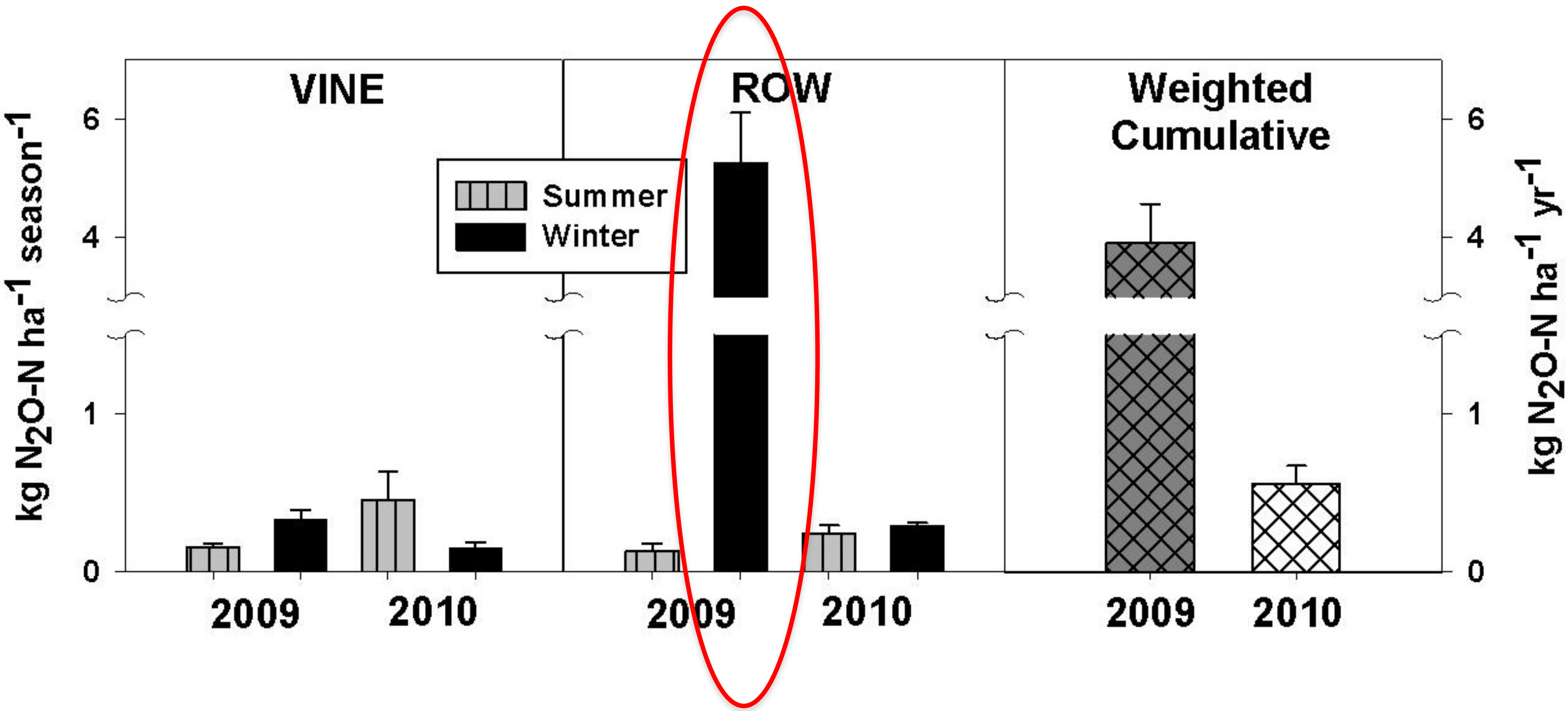


Processing Tomatoes

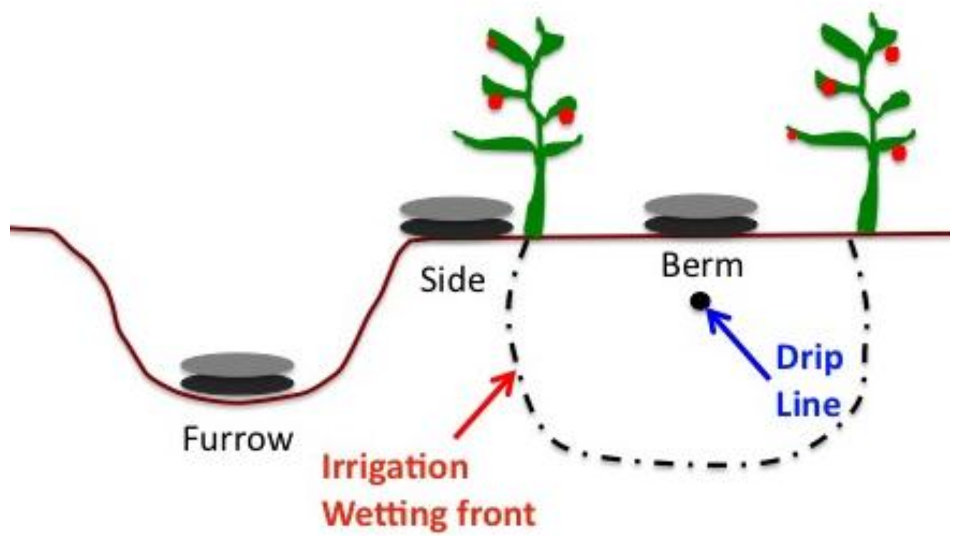
Typical Management Regimes

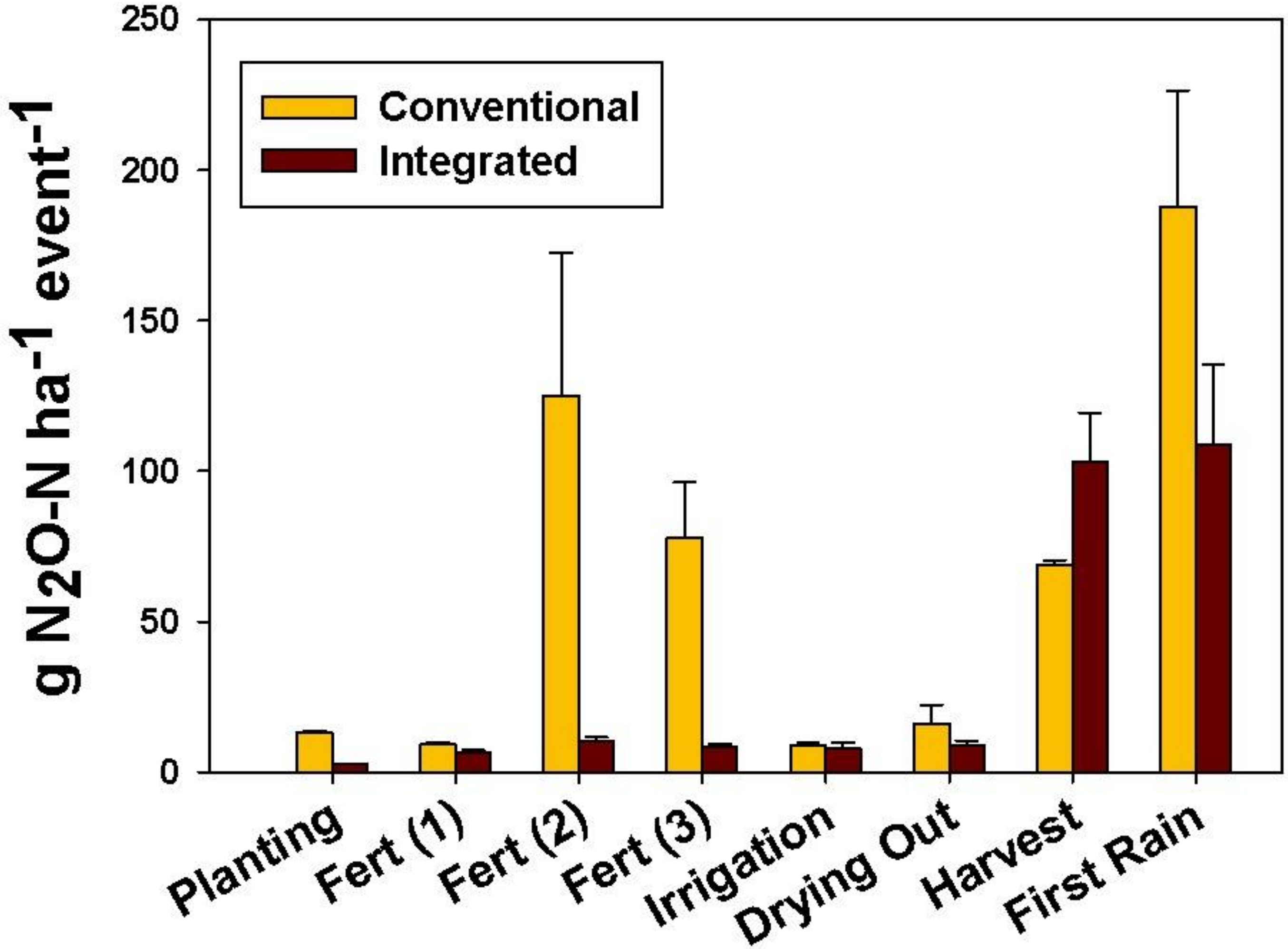
Conventional

- Conventional Tillage
- Furrow Irrigation
- Rip and Reform Beds

Integrated

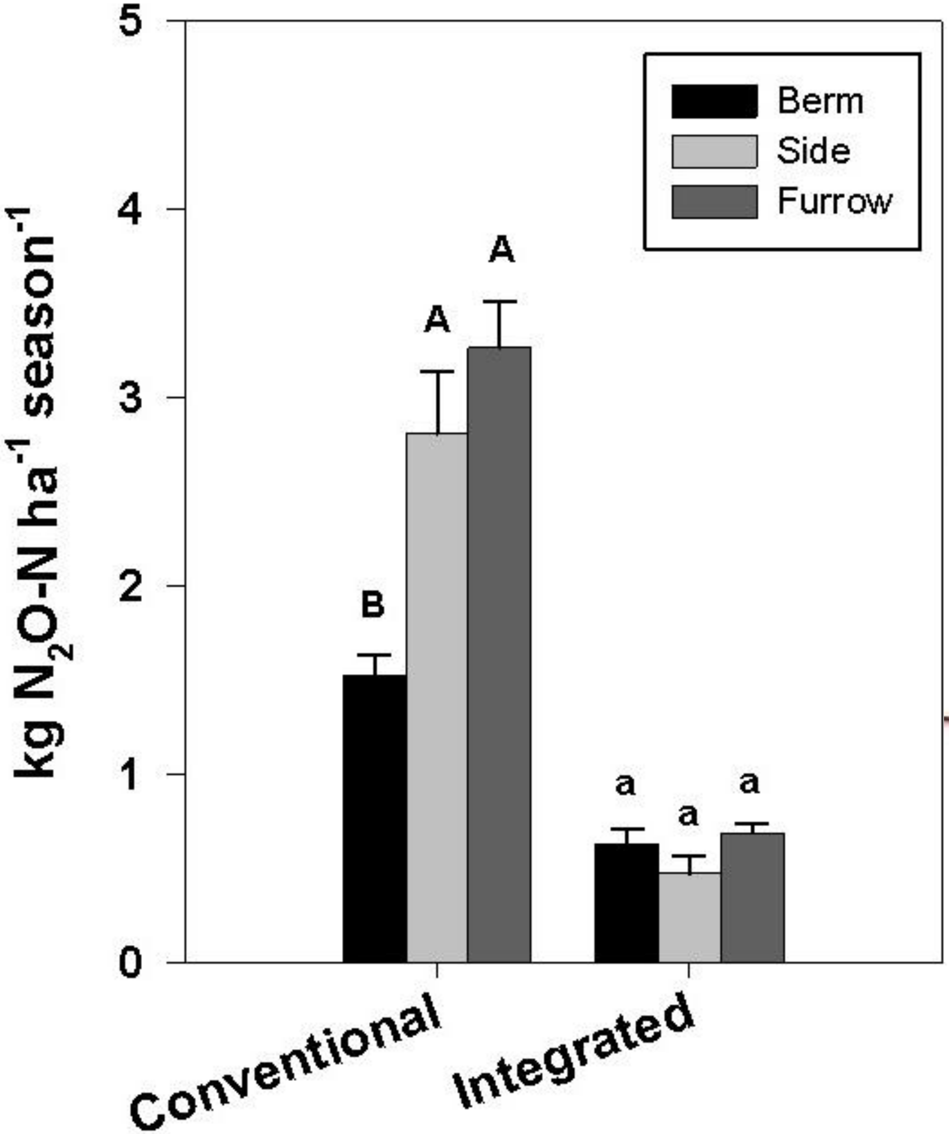
- Reduced Tillage
- Subsurface Drip Irrigation
- Winter Grain Cover Crop
- Preserve Planting Beds

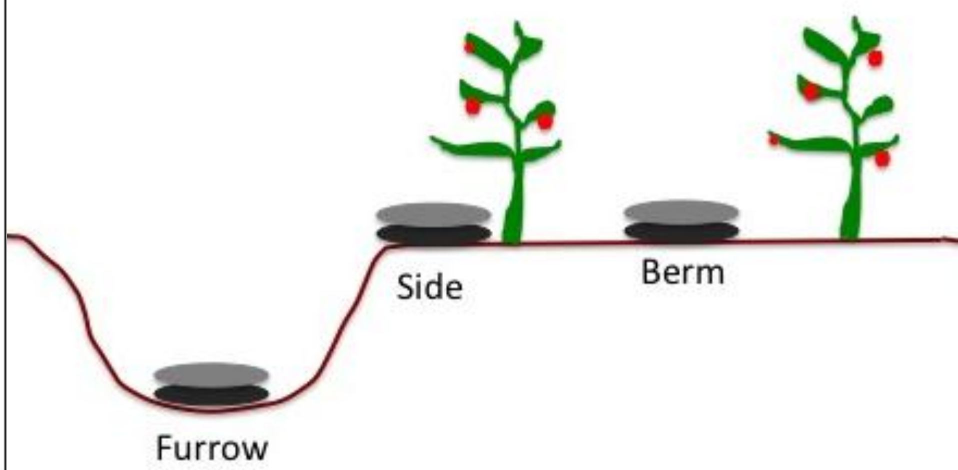


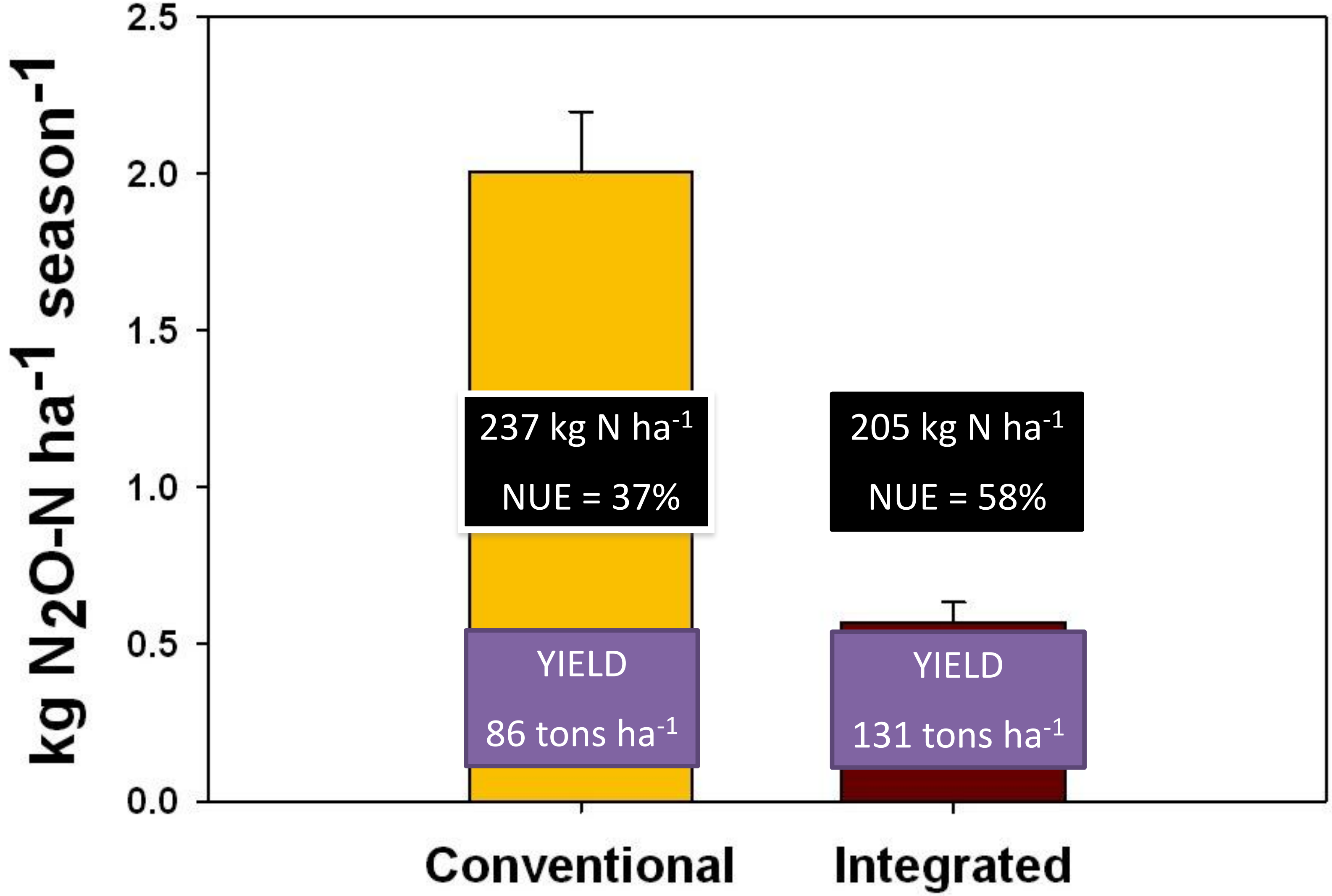


Kennedy et al. ***in prep***

Spatial Variability by Management

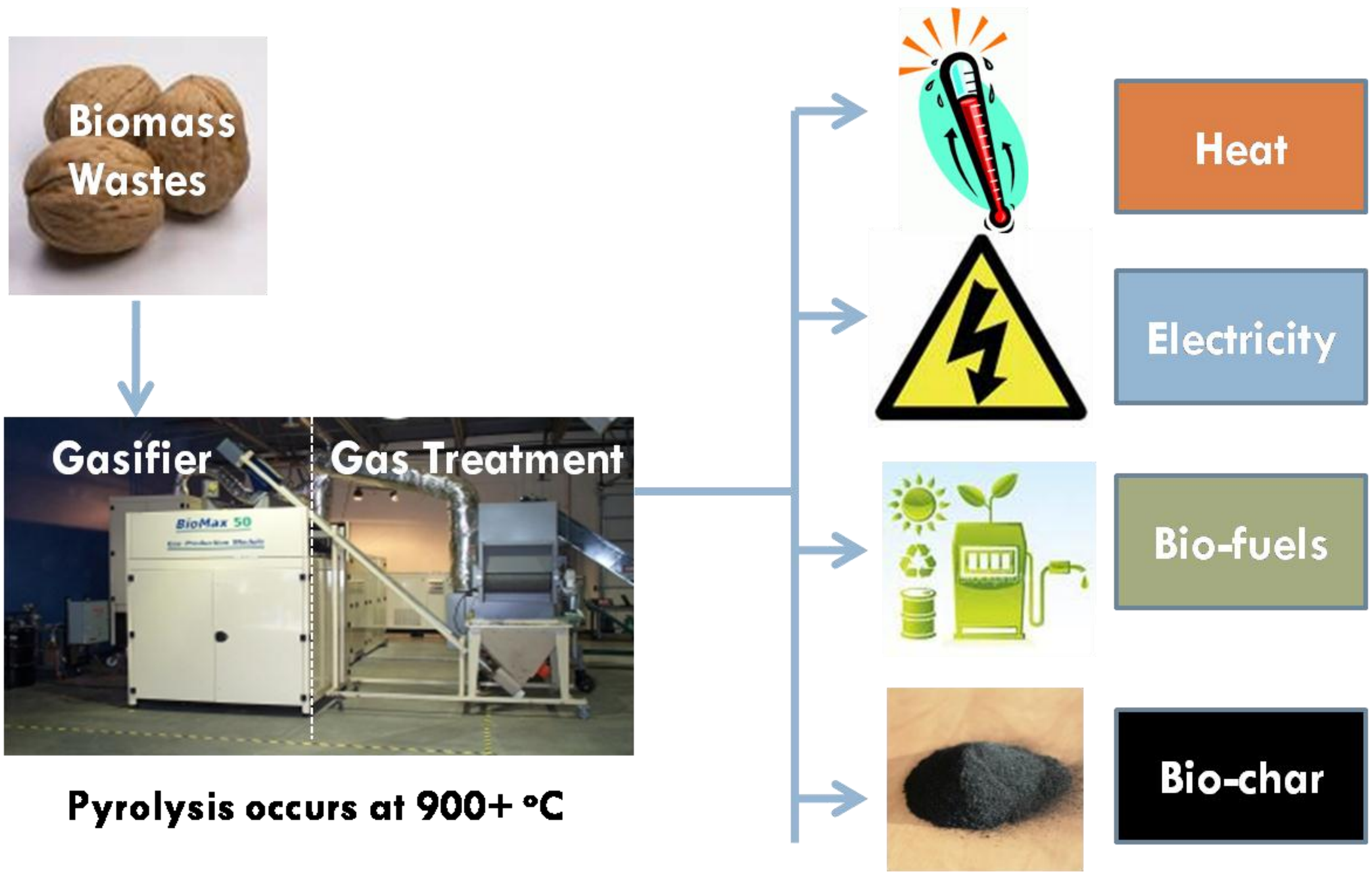






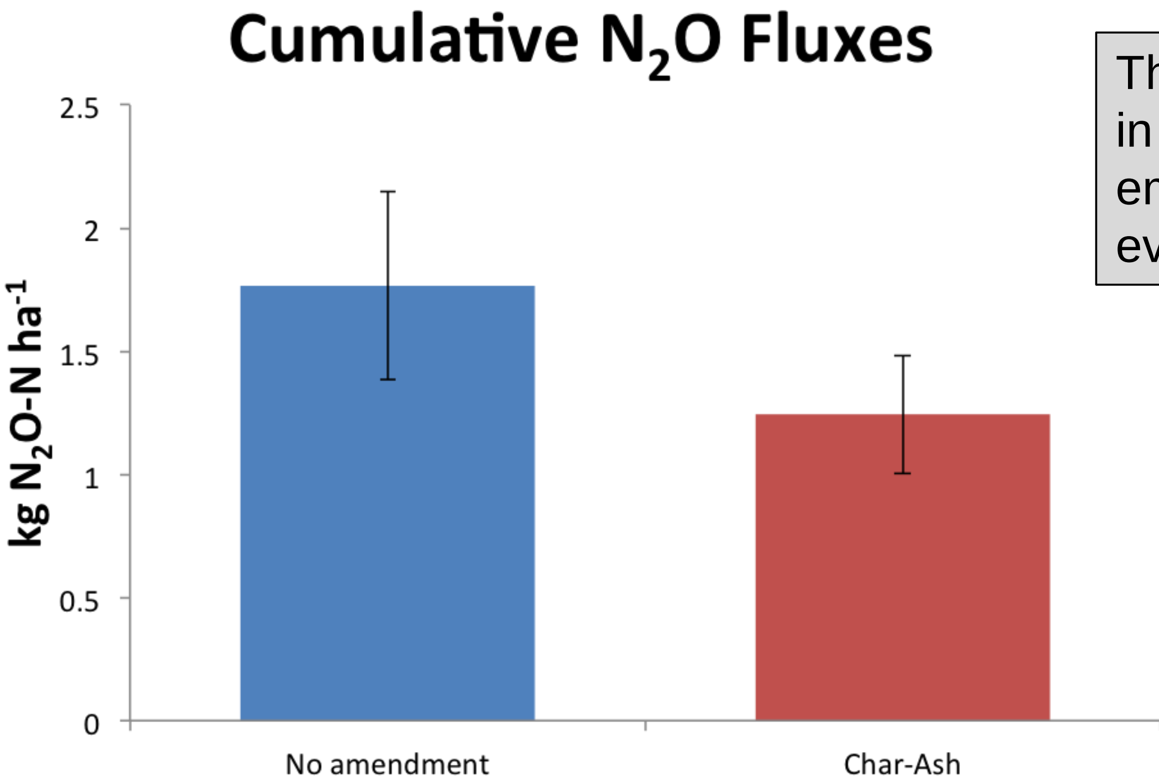
Kennedy et al. ***in prep***

Biochar



Biomass Wastes
Gasifier
Gas Treatment
BioMax 50
Pyrolysis occurs at 900+ °C
Heat
Electricity
Bio-fuels
Bio-char

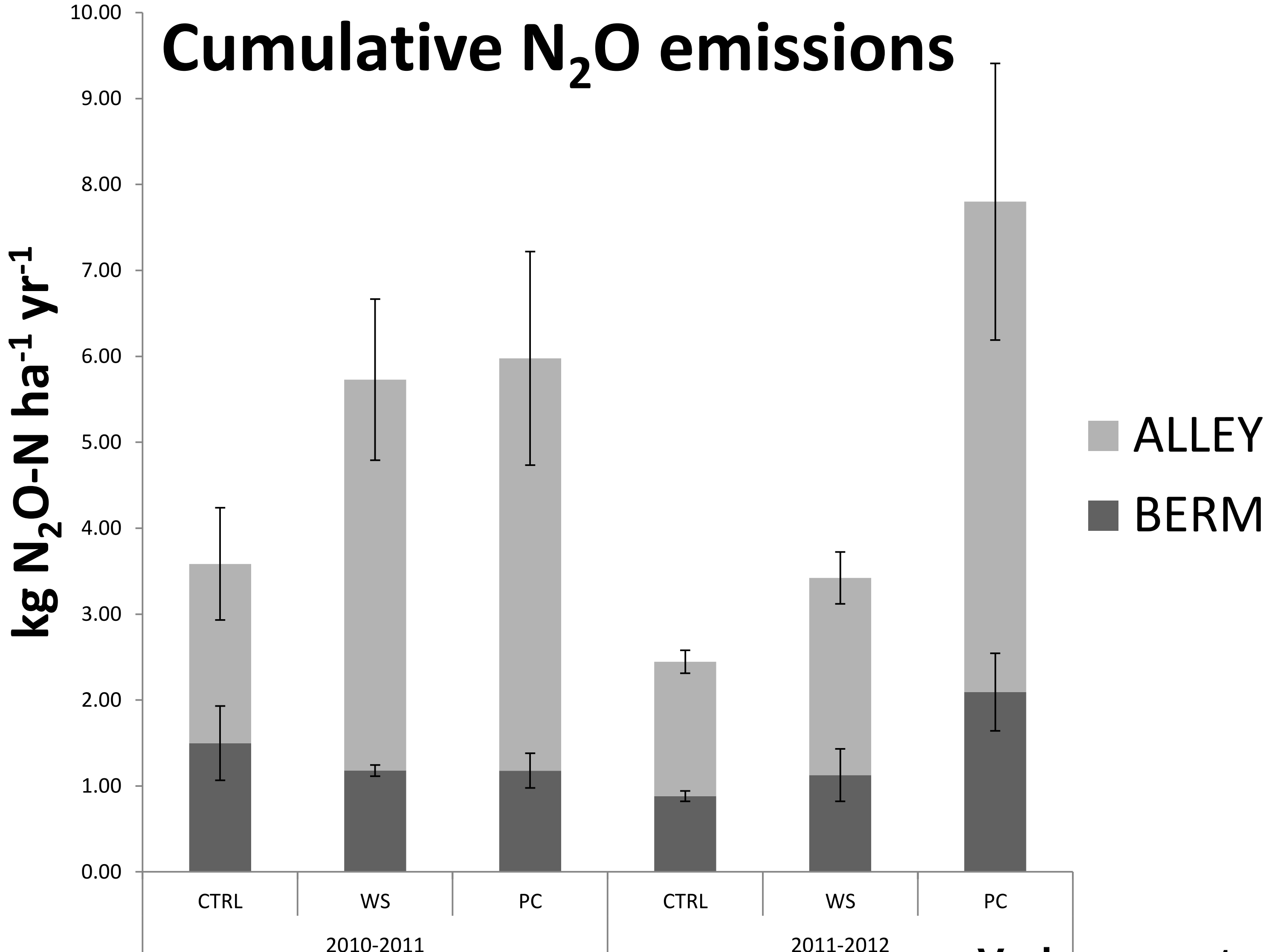
Reduces N_2O emissions in Walnut



The incorporation of Char-Ash in the soil reduced N_2O emissions, especially during wet events.

Pereira et al. *in prep*

Increases N_2O emissions in Vineyard



Verhoeven et al. *in prep*

Summary annual N_2O emissions

Cropping system	Management	N_2O flux kg N_2O-N ha^{-1}	N input rate kg N ha^{-1} yr^{-1}	Emission Factor %
Almond	BAU*			0.35
Vineyard	BAU			7.5
	BAU			10.4
	BAU			***0.33***
	Biochar			***0.65***
	Biochar			***0.82***
Walnut	Organic			1.17
	Biochar			***1.63***
Tomato	***BAU***			***0.87***
	Integrated			***0.29***
Lettuce	***Organic***			***0.12***
	Biochar			***0.12***

0.12 – 10.4%

Fluxes in bold and italic are seasonal fluxes

***BAU = Business as Usual**

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	Biochar			***1.63***
Tomato	***BAU***			***0.87***
	Integrated			***0.29***
Lettuce	***Organic***			***0.12***
	Biochar			***0.12***

0.66 – 10.4 %

Fluxes in bold and italic are seasonal fluxes

***BAU = Business as Usual**

Conclusions

- No silver bullets for N_2O mitigation; even biochar…
- Simple emission factors fail → under- and overestimation
- N_2O can be reduced without a yield penalty!

Acknowledgements

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Thank you!